

**In the claims:**

**Amend claims 1-46 where indicated.**

1           1.       (Currently Amended)   In a magnetic read head having an air bearing surface  
2       (ABS), a magnetic tunnel junction (MTJ) sensor for connection to sense circuitry for detecting  
3       changes in electrical resistance within the sensor, the sensor comprising:

4           a MTJ stack with an active region disposed at the ABS and having ~~two opposite~~ oppositely  
5       facing first and second sides each disposed generally orthogonally to the ABS, the MTJ stack  
6       comprising:

7           an antiferromagnetic (AFM) layer spanning the active region,

8           a pinned layer of ferromagnetic (FM) material in contact with the AFM layer,

9           a free layer of FM material spanning the active region and ~~extending beyond each~~  
10       ~~of the two opposite sides thereof, and~~ having first and second free layer extensions which  
11       extend in opposite directions from the first and second sides respectively;

12          a tunnel junction layer of electrically nonconductive material disposed between the  
13       pinned layer and the free layer in the active region; [[and]]

14          the AFM, pinned, free and tunnel junction layers having parallel surfaces which  
15       extend between the first and second sides and are orthogonal with respect to the ABS; and

16          the first and second free layer extensions having first and second top surfaces  
17       which are parallel with respect to the parallel surfaces of the AFM, pinned, free and tunnel  
18       junction layers;

19          [[a]] first and second longitudinal bias [[layer]] layers formed on and in contact with the  
20       ~~free layer~~ first and second top surfaces of the free layer extensions outside of the active region for  
21       biasing the magnetic moment of the free layer in substantially a predetermined direction in the  
22       absence of an external magnetic field.

1           2.       (Currently Amended)   The sensor of claim 1 further comprising:

2           an insulating layer of electrically nonconductive material formed on and in contact with  
3       the free layer extensions outside of the active region and in abutting contact with the ~~two opposite~~  
4       first and second sides of the active region.

1 3. (Original) The sensor of claim 2 wherein the longitudinal bias layer is disposed  
2 without contacting the active region.

1 4. (Original) The sensor of claim 3 wherein the longitudinal bias layer comprises  
2 a hard magnetic (HM) material.

1 5. (Withdrawn) The sensor of claim 3 wherein the longitudinal bias layer comprises  
2 an AFM material.

1 6. (Original) The sensor of claim 1 wherein the longitudinal bias layer is disposed  
2 without contacting the active region.

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contd  
2 7. (Original) The sensor of claim 6 wherein the longitudinal bias layer comprises  
a HM material.

1 8. (Withdrawn) The sensor of claim 6 wherein the longitudinal bias layer comprises  
2 an AFM material.

1 9. (Withdrawn) The sensor of claim 1 further comprising:  
2 the longitudinal bias layer comprises an electrically nonconductive AFM material disposed  
3 outside of the active region and in abutting contact with the two opposite sides of the active  
4 region.

1 10. (Withdrawn) The sensor of claim 1 wherein the longitudinal bias layer comprises  
2 an electrically nonconductive HM material disposed outside of the active region and in abutting  
3 contact with the two opposite sides of the active region.

1 11. (Currently Amended) A direct access storage device (DASD) comprising:  
2 a magnetic recording disk having at least one surface for storing magnetically recorded  
3 data;  
4 a magnetic read head having an air bearing surface (ABS) disposed for reading the data  
5 from the magnetic recording disk surface;

6 in the magnetic read head, a magnetic tunnel junction (MTJ) sensor comprising:  
7 a MTJ stack with an active region disposed at the ABS and having ~~two opposite~~  
8 oppositely facing first and second sides each disposed generally orthogonally to the ABS,  
9 the MTJ stack comprising:  
10 an antiferromagnetic (AFM) layer spanning the active region,  
11 a pinned layer of ferromagnetic (FM) material in contact with the AFM  
12 layer,  
13 a free layer of FM material spanning the active region and ~~extending~~  
14 ~~beyond each of the two opposite sides thereof, and~~ having first and second free  
15 layer extensions which extend in opposite directions from the first and second  
16 sides respectively;  
17 a tunnel junction layer of electrically nonconductive material disposed  
18 between the pinned layer and the free layer in the active region; ~~[[and]]~~  
19 the AFM, pinned, free and tunnel junction layers having parallel surfaces  
20 which extend between the first and second sides and are orthogonal with respect  
21 to the ABS; and  
22 the first and second free layer extensions having first and second top  
23 surfaces which are parallel with respect to the parallel surfaces of the AFM,  
24 pinned, free and tunnel junction layers;  
25 ~~[[a]]~~ first and second longitudinal bias ~~[[layer]]~~ layers formed on and in contact with the  
26 ~~free layer~~ first and second top surfaces of the free layer extensions outside of the active region for  
27 biasing the magnetic moment of the free layer in substantially a predetermined direction in the  
28 absence of an external magnetic field;  
29 an actuator for moving the magnetic read head across the magnetic recording disk surface  
30 to access the data stored thereon; and  
31 a data channel having sense circuitry coupled electrically to the MTJ sensor for detecting  
32 changes in resistance of the MTJ sensor caused by rotation of the magnetic moment of the free  
33 ferromagnetic layer relative to the fixed magnetic moment of the pinned layer responsive to  
34 magnetic fields representing the data stored on the ~~magnet~~ magnetic recording disk surface.

1           12.     (Currently Amended)   The DASD of claim 11 further comprising:  
2     an insulating layer of electrically nonconductive material formed on and in contact with the free  
3     layer outside of the active region and in abutting contact with the [[two]] first and second opposite  
4     sides of the active region.

1           13.     (Original)       The DASD of claim 12 wherein the longitudinal bias layer is  
2     disposed without contacting the active region.

1           14.     (Original)       The DASD of claim 13 wherein the longitudinal bias layer  
2     comprises a hard magnetic (HM) material.

AT cont'd  
2           15.     (Withdrawn)   The DASD of claim 13 wherein the longitudinal bias layer  
2     comprises an AFM material.

1           16.     (Original)       The DASD of claim 11 wherein the longitudinal bias layer is  
2     disposed without contacting the active region..

1           17.     (Original)       The DASD of claim 16 wherein the longitudinal bias layer  
2     comprises a HM material.

1           18.     (Withdrawn)   The DASD of claim 16 wherein the longitudinal bias layer  
2     comprises an AFM material.

1           19.     (Withdrawn)   The DASD of claim 11 further comprising:  
2     the longitudinal bias layer comprises an electrically nonconductive AFM material disposed outside  
3     of the active region and in abutting contact with the two opposite sides of the active region.

1           20.     (Withdrawn)   The DASD of claim 11 wherein the longitudinal bias layer  
2     comprises an electrically nonconductive AFM material disposed outside of the active region and  
3     in abutting contact with the two opposite sides of the active region.

1           21.   (Withdrawn) In a magnetic read head having an air bearing surface (ABS), a  
2 magnetic tunnel junction (MTJ) sensor for connection to sense circuitry for detecting changes in  
3 electrical resistance within the sensor, the sensor comprising:

4           a MTJ stack with an active region disposed at the ABS and having two opposite sides each  
5 disposed generally orthogonally to the ABS, the MTJ stack comprising:

6                   an antiferromagnetic (AFM) layer spanning the active region,

7                   a pinned layer of ferromagnetic (FM) material in contact with the AFM layer,

8                   a free layer of FM material spanning the active region, and

9                   a tunnel junction layer of electrically nonconductive material disposed between the  
10 pinned layer and the free layer in the active region; and

11           a nonconductive longitudinal bias layer formed outside of the active region and in abutting  
12 contact with the two opposite sides of the active region for biasing the magnetic moment of the  
13 free layer in substantially a predetermined direction in the absence of an external magnetic field.

14           22.   (Withdrawn) The sensor of claim 21 wherein the nonconductive longitudinal bias  
15 layer comprises a hard magnetic (HM) material.

16           23.   (Withdrawn) A direct access storage device (DASD) comprising:

1           a magnetic recording disk having at least one surface for storing magnetically recorded  
2 data;

3           a magnetic read head having an air bearing surface (ABS) disposed for reading the data  
4 from the magnetic recording disk surface;

5           in the magnetic read head, a magnetic tunnel junction (MTJ) sensor comprising:

6                   a MTJ stack with an active region disposed at the ABS and having two opposite  
7 sides each disposed generally orthogonally to the ABS, the MTJ stack comprising:

8                   an antiferromagnetic (AFM) layer spanning the active region,

9                   a pinned layer of ferromagnetic (FM) material in contact with the AFM layer,

10                   a free layer of FM material spanning the active region, and

11                   a tunnel junction layer of electrically nonconductive material disposed between the  
12 pinned layer and the free layer in the active region; and

13           a nonconductive longitudinal bias layer formed outside of the active region and in abutting  
14 contact with the two opposite sides of the active region for biasing the magnetic moment of the  
15 free layer in substantially a predetermined direction in the absence of an external magnetic field;  
16

17 an actuator for moving the magnetic read head across the magnetic recording disk surface  
18 to access the data stored thereon; and

19 a data channel having sense circuitry coupled electrically to the MTJ sensor for detecting  
20 changes in resistance of the MTJ sensor caused by rotation of the magnetic moment of the free  
21 ferromagnetic layer relative to the fixed magnetic moment of the pinned layer responsive to  
22 magnetic fields representing the data stored on the magnetic recording disk surface.

1 24. (Withdrawn) The sensor of claim 23 wherein the nonconductive longitudinal bias  
2 layer comprises a hard magnetic (HM) material.

1 25. (Withdrawn) A method for fabricating a magnetic tunnel junction (MTJ) sensor  
2 for use in a magnetic read head having an air bearing surface (ABS), the method comprising the  
unordered steps of:

3 (a) forming a MTJ stack with an active region disposed at the ABS and having two  
4 opposite sides each disposed generally orthogonally to the ABS, including the unordered steps of:

5 (a.1) forming an antiferromagnetic (AFM) layer,

6 (a.2) forming a pinned layer of ferromagnetic (FM) material in contact with the AFM  
7 layer,  
8

9 (a.3) forming a free layer of FM material,

10 (a.4) forming a tunnel junction layer of electrically nonconductive material disposed  
11 between the pinned layer and the free layer, and

12 (a.5) removing all material outside of the active region from the AFM layer, the pinned  
13 layer, and the tunnel junction layer to define the two opposite sides of the active region; and

14 (b) forming a longitudinal bias layer outside of the active region in contact with the  
15 free layer for biasing the magnetic moment of the free layer in substantially a predetermined  
16 direction in the absence of an external magnetic field.

1 26. (Withdrawn) The method of claim 25 further comprising the step of:

2 (c) forming an insulating layer of electrically nonconductive material on and in contact  
3 with the free layer outside of the active region and in abutting contact with the two opposite sides  
4 of the active region.

1 27. (Withdrawn) The method of claim 26 wherein the longitudinal bias layer is  
2 disposed without contacting the active region.

1 28. (Withdrawn) The method of claim 27 wherein the longitudinal bias layer  
2 comprises a hard magnetic (HM) material.

1 29. (Withdrawn) The method of claim 27 wherein the longitudinal bias layer  
2 comprises an AFM material.

1 30. (Withdrawn) The method of claim 25 wherein the longitudinal bias layer is  
2 disposed without contacting the active region.

1 31. (Withdrawn) The method of claim 30 wherein the longitudinal bias layer  
2 comprises a HM material.

1 32. (Withdrawn) The method of claim 30 wherein the longitudinal bias layer  
2 comprises an AFM material.

1 33. (Withdrawn) The method of claim 25 wherein the forming step (b) further  
2 comprises the step of:

3 (b.1) forming a nonconductive longitudinal bias layer outside of the active region and  
4 in abutting contact with the two opposite sides of the active region for biasing the magnetic  
5 moment of the free layer in substantially a predetermined direction in the absence of an external  
6 magnetic field.

1 34. (Withdrawn) The sensor of claim 33 wherein the nonconductive longitudinal bias  
2 layer comprises a HM material.

1 35. (Withdrawn) The sensor of claim 33 wherein the nonconductive longitudinal bias  
2 layer comprises an AFM material.

1 36. (Withdrawn) The method of claim 25 wherein the removing step (a.5) further  
2 comprises the step of:

3 (a.5.1) removing all material outside of the active region from the AFM layer, the pinned  
4 layer, the tunnel junction layer and the free layer to define the two opposite sides of the active  
5 region.

1 37. (Withdrawn) The method of claim 36 wherein the forming step (b) further  
2 comprises the step of:

3 (b.1) depositing additional FM material on the free layer in the active region and beyond  
4 the two opposite sides of the active region.

1 38. (Withdrawn) The method of claim 37 further comprising the step of:  
2 (c) forming an insulating layer of electrically nonconductive material on and in contact  
3 with the free layer outside of the active region and in abutting contact with the two opposite sides  
4 of the active region.

1 39. (Withdrawn) The method of claim 38 wherein the longitudinal bias layer is  
2 disposed without contacting the active region.

1 40. (Withdrawn) The method of claim 39 wherein the longitudinal bias layer  
comprises a hard magnetic (HM) material.

2 41. (Withdrawn) The method of claim 39 wherein the longitudinal bias layer  
comprises an AFM material.

1 42. (Withdrawn) The method of claim 37 wherein the longitudinal bias layer is  
2 disposed without contacting the active region.

1 43. (Withdrawn) The method of claim 42 wherein the longitudinal bias layer  
2 comprises a HM material.

1 44. (Withdrawn) The method of claim 42 wherein the longitudinal bias layer  
2 comprises an AFM material.

1 45. (Withdrawn) The method of claim 36 wherein the forming step (b) further  
2 comprises the step of:

3 (b.1) forming a nonconductive longitudinal bias layer outside of the active region and  
4 in abutting contact with the two opposite sides of the active region for biasing the magnetic  
5 moment of the free layer in substantially a predetermined direction in the absence of an external  
6 magnetic field.

1 46. (Withdrawn) The method of claim 45 wherein the nonconductive longitudinal  
2 bias layer comprises a hard magnetic (HM) material.



**Add new claims 47-52.**

1           47. (New) A magnetic tunnel junction sensor, which has an air bearing surface  
2 (ABS), comprising:  
3           a ferromagnetic pinned layer having a magnetic moment;  
4           an antiferromagnetic (AFM) pinning layer exchange coupled to the pinned layer for  
5 pinning the magnetic moment of the pinned layer perpendicular to the ABS;  
6           a ferromagnetic free layer having a magnetic moment parallel to the ABS;  
7           a nonconductive and nonmagnetic spacer layer located between the free and pinned layers;  
8           each of the AFM, pinned, spacer and free layers having first and second side surfaces  
9 which are orthogonal with respect to the ABS with the first side surfaces of the AFM, pinned  
10 spacer and free layers being contiguous and the second side surfaces of the AFM, pinned, spacer  
11 and free layers being contiguous;  
12           each of the AFM, pinned, spacer and free layers having major thin film surfaces which  
13 extend between the first and second side surfaces, are orthogonal with respect to the ABS and are  
14 parallel with respect to one another;  
15           the free layer having laterally extending first and second side extensions which extend in  
16 opposite directions from the first and second side surfaces respectively of the free layer with each  
17 of the first and second side extensions having a top surface which is orthogonal with respect to the  
18 ABS and parallel with respect to said major thin film surfaces;  
19           first and second longitudinal bias layers interfacing the top surfaces of the first and second  
20 side extensions and spaced from the first and second side surfaces respectively of the free layer  
21 so as to leave first and second top surface portions respectively between the first and second  
22 longitudinal bias layers and the first and second side surfaces respectively of the free layer which  
23 are not interfaced by the first and second longitudinal bias layers; and  
24           nonconductive and nonmagnetic first and second insulation layers interfacing the first and  
25 second side surfaces respectively of the AFM, pinned, spacer and free layers, the first and second  
26 top surface portions respectively and the first and second longitudinal bias layers respectively.

1           48. (New) The sensor as claimed in claim 47 wherein the first and second  
2 longitudinal bias layers are composed of a hard magnetic material.

49. (New) A magnetic read head, which has an air bearing surface (ABS), comprising:  
first and second lead layers;  
a magnetic tunnel junction (MTJ) sensor located between and in electrical contact with the  
first and second lead layers;  
the MTJ sensor comprising:  
a ferromagnetic pinned layer having a magnetic moment;  
an antiferromagnetic (AFM) pinning layer exchange coupled to the pinned layer  
for pinning the magnetic moment of the pinned layer perpendicular to the ABS;  
a ferromagnetic free layer having a magnetic moment parallel to the ABS;  
a nonconductive and nonmagnetic spacer layer located between the free and pinned  
layers;  
each of the AFM, pinned, spacer and free layers having first and second side  
surfaces which are orthogonal with respect to the ABS with the first side surfaces of the  
AFM, pinned spacer and free layers being contiguous and the second side surfaces of the  
AFM, pinned, spacer and free layers being contiguous; and  
each of the AFM, pinned, spacer and free layers having major thin film surfaces  
which extend between the first and second side surfaces, are orthogonal with respect to the  
ABS and are parallel with respect to one another;  
first and second longitudinal bias layers interfacing the top surfaces of the first and second  
side extensions and spaced from the first and second side surfaces respectively of the free layer  
so as to leave first and second top surface portions respectively between the first and second  
longitudinal bias layers and the first and second side surfaces respectively of the free layer which  
are not interfaced by the first and second longitudinal bias layers; and  
nonconductive and nonmagnetic first and second insulation layers interfacing the first and  
second side surfaces respectively of the AFM, pinned, spacer and free layers, the first and second  
top surface portions respectively and the first and second longitudinal bias layers respectively.

50. (New) The magnetic head as claimed in claim 49 wherein the first and second  
longitudinal bias layers are composed of a hard magnetic material.

1 51. (New) A direct access storage device (DASD) comprising:  
2 a magnetic recording disk having at least one surface for storing magnetically recorded  
3 data;  
4 a magnetic read head having an air bearing surface (ABS) disposed for reading the data  
5 from the magnetic recording disk surface;  
6 in the magnetic read head, a magnetic tunnel junction (MTJ) sensor comprising:  
7 a ferromagnetic pinned layer having a magnetic moment;  
8 an antiferromagnetic (AFM) pinning layer exchange coupled to the pinned layer  
9 for pinning the magnetic moment of the pinned layer perpendicular to the ABS;  
10 a ferromagnetic free layer having a magnetic moment parallel to the ABS;  
11 a nonconductive and nonmagnetic spacer layer located between the free and pinned  
12 layers;  
13 each of the AFM, pinned, spacer and free layers having first and second side  
14 surfaces which are orthogonal with respect to the ABS with the first side surfaces of the  
15 AFM, pinned spacer and free layers being contiguous and the second side surfaces of the  
16 AFM, pinned, spacer and free layers being contiguous;  
17 each of the AFM, pinned, spacer and free layers having major thin film surfaces  
18 which extend between the first and second side surfaces, are orthogonal with respect to the  
19 ABS and are parallel with respect to one another; and  
20 the free layer having laterally extending first and second side extensions which  
21 extend in opposite directions from the first and second side surfaces respectively of the  
22 free layer with each of the first and second side extensions having a top surface which is  
23 orthogonal with respect to the ABS and parallel with respect to said major thin film  
24 surfaces;  
25 first and second longitudinal bias layers interfacing the top surfaces of the first and second  
26 side extensions and spaced from the first and second side surfaces respectively of the free layer  
27 so as to leave first and second top surface portions respectively between the first and second  
28 longitudinal bias layers and the first and second side surfaces respectively of the free layer which  
29 are not interfaced by the first and second longitudinal bias layers;  
30 nonconductive and nonmagnetic first and second insulation layers interfacing the first and  
31 second side surfaces respectively of the AFM, pinned, spacer and free layers, the first and second  
32 top surface portions respectively and the first and second longitudinal bias layers respectively;

33 an actuator for moving the magnetic read head across the magnetic recording disk surface  
34 to access the data stored thereon; and

35 a data channel having sense circuitry coupled electrically to the MTJ sensor for detecting  
36 changes in resistance of the MTJ sensor caused by rotation of the magnetic moment of the free  
37 ferromagnetic layer relative to the fixed magnetic moment of the pinned layer responsive to  
38 magnetic fields representing the data stored on the magnet recording disk surface.

1 52. (New) The sensor as claimed in claim 51 wherein the first and second  
2 longitudinal bias layers are composed of a hard magnetic material.

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